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## Natural Materials - Materiality and construction of sustainable buildings - A one-to-one experience

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AALBORG UNIVERSITET

A&D  
CREATE



**Materiality  
and  
construction  
of sustainable  
buildings**



**A one-to-one  
experience**



# NATURAL MATERIALS



# MATERIALITY AND CONSTRUCTION OF SUSTAINABLE BUILDINGS

## THE POTENTIAL OF LOCAL NATURAL MATERIALS IN ARCHITECTURE

Natural materials are offered with a variety in almost every location. Using their potential in contemporary architecture diminishes the environmental impact of buildings. Distinct local architectural designs can be developed which are suited to the local building tradition and the local climate conditions

This brochure constitutes the practical outcome of an experimental construction process in the course, Materiality and Construction of Sustainable Buildings, which was conducted during the period March 12th – May 10th 2019.

### OBJECTIVES

The aim of the course is to provide an understanding of the diverse and specific qualities of building materials and constructions and their use in contemporary buildings. The course aims at providing an advanced understanding of material theory, experimental methods of working with materials and practice in design and evaluation of sustainable buildings. This includes insight into material performance of selected materials, certification systems as well as appreciation of how materials may be applied and perceived within the architectural realm.

### LEARNINGS FROM THIS COURSE AND REMARKS ON THE 1:1 MODELS

Going from the design phase and detailed drawings to the construction phase and 1:1 modelling has brought awareness of the level of information embedded in the drawings, challenges related to material properties of real materials as opposed to general material characteristics, the importance of tolerances, etc. The process of designing

and constructing the 1:1 model included also to work out a material list, which served to order materials for the workshop. In the further reflection process after having ordered the materials and even during the workshop some groups concluded that their design could be further improved.

Therefore, the material used in these models are in some cases a simulation of the real material to be used. The exhibited 1:1 models therefore express the result of conducted experiments and are not to be regarded as final design solutions.



**Course module:** 5 ECTS

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**Supervisors:** Anne K. Bejder, Tine S. Larsen, Agathe Revil-Signorat, Camilla Brunsgaard, Dario Parigi, Runa T. Hellwig

**Lectures by:** Tine S. Larsen, Anne K. Bejder, Runa T. Hellwig, Camilla Brunsgaard, Marwa Dabaieh, Dario Parigi, Mads B. Jensen

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**Brochure design:** Emilie Hellerup

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# WORKSHOP 1:1 MODELLING WITH LOCAL NATURAL MATERIALS



## EXPERIMENTAL PROCESS

The course comprises of two phases, which strengthen the student's ability to analyse, design, experiment, construct and critically reflect on the choice and application of natural materials in sustainable buildings. The course has included a combination of theoretical studies, lectures, design development (Phase 1), testing and constructing in scale 1:1 (Phase 2).

During the first phase, the students were introduced to life cycle assessment (LCA) of materials, constructions and buildings. Each student had to evaluate variations of a wall construction using natural materials and comparing it to conventional wall constructions. Based on the learning from the evaluation result of each student the groups decided on a wall design.

The groups chose to work with one of the following natural construction materials: reeds, seaweed, hemp, cellulose, earth (rammed earth or dried clay bricks) or different timber products, and the construction was to be designed with an eye to future "disassembly".

## PARTICIPATING STUDENTS

Mette Sletting Jensen, Mathilde Vig Benfeldt, Tine Bredahl Terkelsen, Andreas Nygaard Mathiesen, Christine Damlund, Luna Nørgaard, Gevitz, Even Årslund Anderssen, Cecilie Bruun Jensen, Benjamin Rusch, Tanja Krogh Andersen, Morten Høgh Larsen, Mikkel Jong, Lykkegaard Pedersen, Gülay Eryüce, Søren Peter Nørgaard Mikkelsen, Christian Rejkjær Bülow, Clara Kirstine Simonsen, Rebecca Butler, Camilla Bjørcklund, Clarissa Nazzaro, Emilie Grønborg Rønnow Nielsen, Julie Melchior Skov, Camilla Hyttel, Luisa Vitolo, Barbara Høyer Johansen, Patrick Jørgensen, Kirstine Tone Hylleberg Beyer, Louise Bagge Mikkelsen, Maria Engelund, Abhay Kumar Kandula, Drashti Shantiv Mehta, Eleni Iro Papadopoulou, Natalia Maria Glapiak



During the second - experimental construction - phase, eight groups of 1 to 5 students have further improved their design, worked out a material order list, evaluated and constructed a 1:1 section of an exterior wall, focusing, among others, on the:

- *Materials' environmental impact (through Life Cycle Analysis)*
- *Materiality of materials (how the materials are perceived)*
- *Technical performance of the materials regarding thermal conductivity and water vapour diffusion*
- *Meeting between materials*
- *Design for disassembly*





# MATERIALITY AND CONSTRUCTION OF SUSTAINABLE BUILDINGS

GROUP 2 - MSC\_Q2 ARCH SUSTAINABILITY



THE FINAL REEDS FACADE



CUTTING THE SEAWEED BATTENS WITH A KNIFE



INSTALLATION LAYER



## DESIGN AND QUALITIES

Egholm is an oasis in the middle of Limfjorden, yet still connected to the busy metropol, Aalborg. On Egholm you can feel isolated from the city life and feel re-connected with nature, by the sound of the waves from the fjord hitting the shore and the sound of the reeds wavering in the wind, tuning out the sound of cars and ecco from hard surfaces. The construction site includes long views over a

flat wild field, a surrounding atmosphere by the tall trees and a dreamy feeling from the landscape of reeds, connecting the site to the water. The choice of materials will bind the building to the surrounding nature and create awareness on natural materials, in both a traditional and new manner. The aim of the choices is to leave a small carbon-footprint by using natural and local materials.



WALL FROM INSIDE



SPACKLE THE CLAYTEC BOARD WITH MOTOR



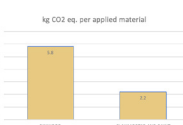
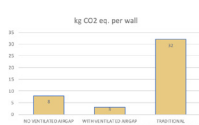
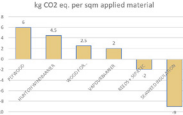
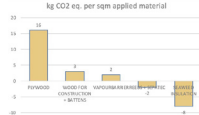
THATCHING THE REEDS ON THE FACADE

## LIFE CYCLE ASSESSEMENT

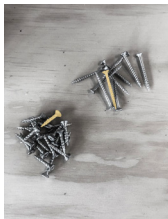
The LCA-analysis shows, that the reellgrass and reeds actually consumes more CO<sub>2</sub> than it releases during its whole lifetime. In principle this means, that the more reellgrass and reeds included in the wall, the less harmful the total CO<sub>2</sub> footprint will be. Though, this will have impact on the LCC-analysis, where a high use of any kind of material will have a negative impact.

Changing the inner cladding to clay, halves the CO<sub>2</sub> for the wall, compared to plywood. Here also the wanted atmosphere has to be considered.

Compared to a traditional timber wall, consisting of different layers of timber cladding, battens, plywood and rockwool, the wall B with no air gap is considered four times better per square meter. In a building perspective, this is an enormous difference for the total carbon footprint.



DISASSEMBLY FRIENDLY



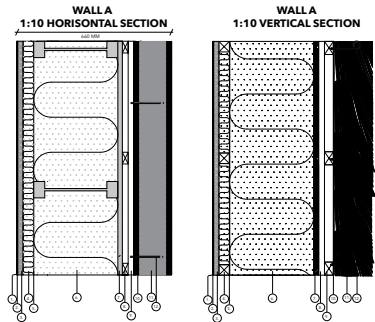
STANDARD JOINTS



CENTRAL STRUCTURAL CORE

The different construction-layers in the climate screens, can be taken apart layer by layer. The materials of the building can hereby be reused as new building material or decomposed as clean materials.

By having a structural core, it is possible to remove each layer from the outside and the inside, when constructing and deconstructing, while the building is still standing.



WALL A: WITH AIRGAPS

WALL B: WITHOUT AIRGAPS

## PROS

- Sustainable material of wind barrier
- Construction behind reeds cladding is the same as behind wood (on cladding project)
- Reeds are not a part of the heated area - only 460 mm of the wall is heated

## CONS

- Glass fiber sheet is used as fire protection
- Big amount of insulation
- Wall thickness of 660 mm
- More material used

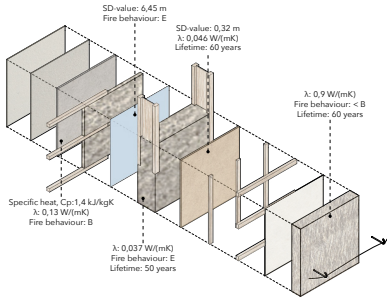
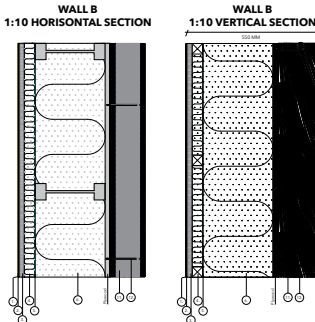
## PROS

- U-value of reeds counts in the overall u-value
- Thinner wall of 550 mm
- Less use of material
- Joints of facades needs no air gap

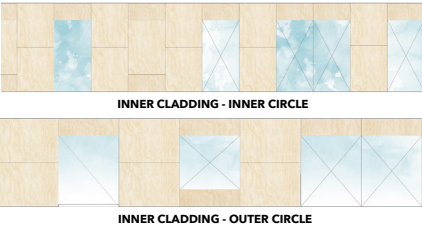
## CONS

- Higher use of plywood
- Construction behind reeds differs from the one behind wood (project)
- Reeds are a part of the heated area and all 550 mm are heated

U-VALUE FOR BOTH WALLS: 0,095 W/m<sup>2</sup>K

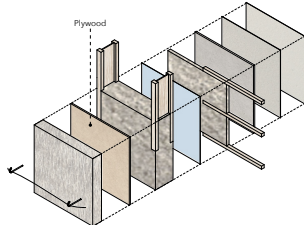


EXPLODED AXONOMETRIC DRAWING WALL A



INNER CLADDING - INNER CIRCLE

INNER CLADDING - OUTER CIRCLE



EXPLODED AXONOMETRIC DRAWING WALL B

## INNER FINISH

CLAYTEC PAINT 2MM  
CLAYTEC FINE CLAY MOTOR 23MM  
Clay contributes with a great acoustic and a good indoor environment, because of it's porosity and as it's a moisture regulating material. It is not burned, which make it easily absorb and release the moisture (1).

## CLAYBOARDS

CLAYTEC CLAYBOARDS 22MM  
Clay boards are a combination of clay, reed and hessian and have great thermal and vapour diffusion properties. The boards can regulate temperature, and are able to absorb and release moisture (2).

## INSTALLATION LAYER

SEAWEED & TIMBER BATTENS (40x60x60MM)  
All the installations run in this layer to avoid breaking the vapour barrier. This paper based vapour barrier secures that moisture can diffuse controlled through the insulation (3).

## VAPOUR BARRIER

SEAWEED & TIMBER CONSTRUCTION 20MM  
Diffusion open vapour barrier secures a breathable construction. It is made of 100% renewable and reusable materials and produced by means of renewable energy and low energy consumption (4).

## INSULATION LAYER

HUNTON WIND BARRIER 19MM  
This wind barrier stores the moisture and prevent condensation. The Hunton barrier is wind resistant, reduces thermal bridges and works as an insulation layer. In addition, it is made of renewable materials (5).

## VENTILATED AIRGAP

TIMBER BATTENS & AIRGAP 25MM  
The original thatched roof method was with fire protection and a ventilated air gap behind the reeds. Nowadays, the reeds can be attached directly on a plywood board and there is no need of fire protection (6).

## FIRE PROTECTION

SEPADEC FIRE PROTECTION  
This fire protection consists of a glass fibre mat and an edge protection. The glass fibre mat will melt when the temperature exceeds 800 degrees. When it is placed close to the reeds layer, the fire can not behave itself (6).

## CLADDING

REEDS 150MM  
THATCHING SPARS & RONTREAD  
The roof pitch should at least be 45 degrees to avoid moisture penetrate through the reeds layer. For every 5 degrees the roof drops, the lifetime increases with 10 years (7).

EXAMPLE OF PROJECT POSTER



## MATERIALITY AND CONSTRUCTION OF SUSTAINABLE BUILDINGS

ARCHITECTURE | MASTER OF SCIENCE & ENGINEERING

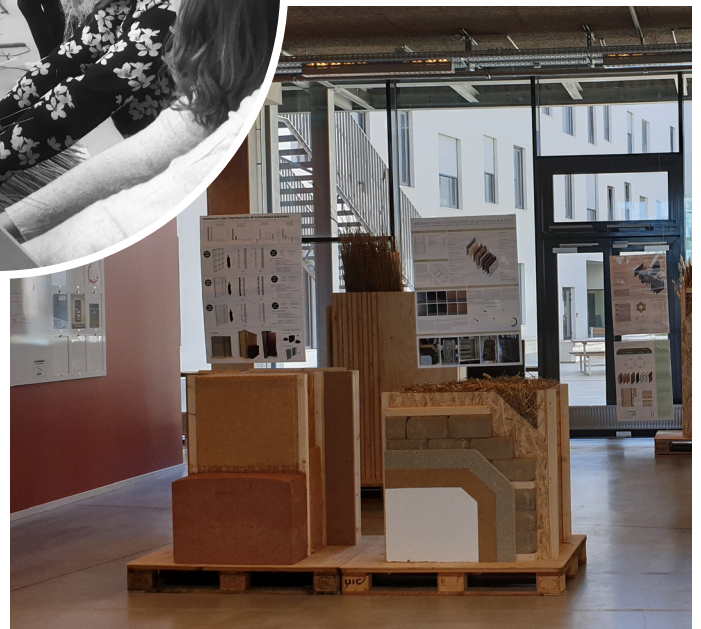
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